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REGULAR FEATURES

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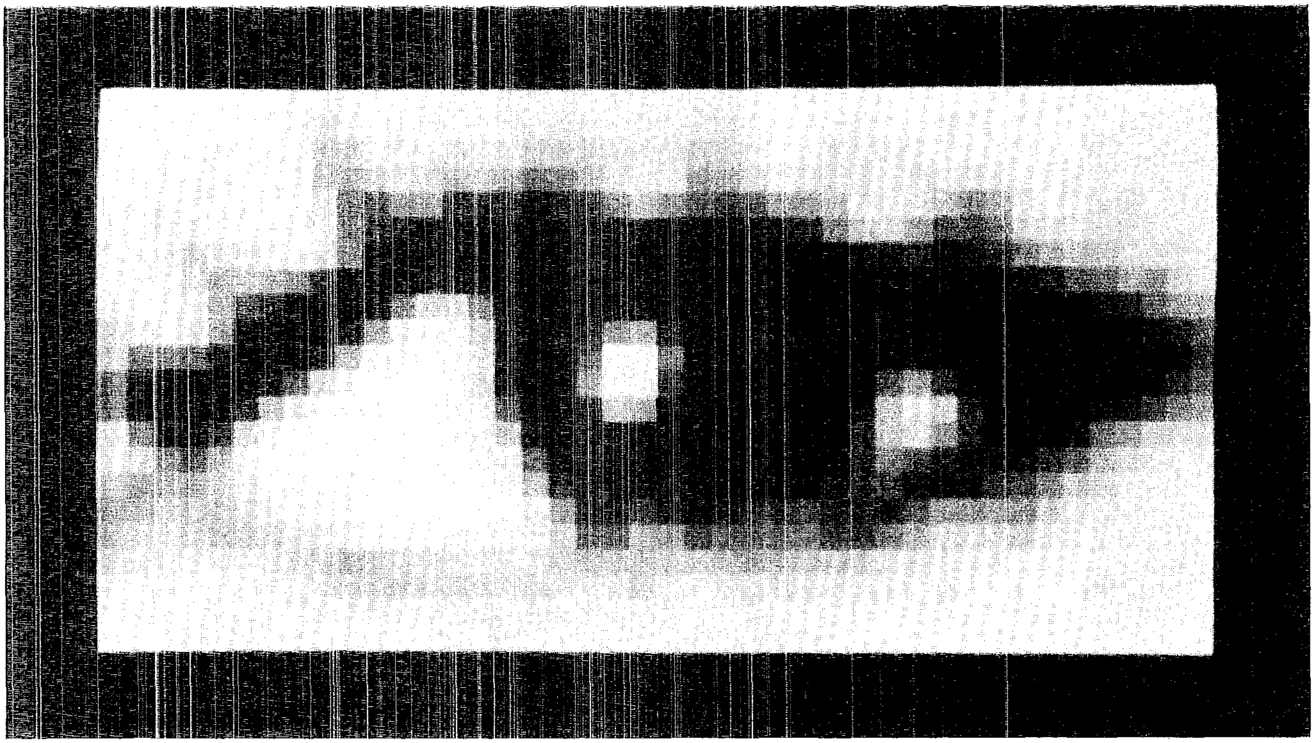
COVER

Drums beat, horns blared, and bells rang in Los Alamos during the Fourth of July weekend as residents turned out in droves to celebrate our country's 200th birthday in grand and glorious style. Recreating an immortal image of the Spirit of '76 in their own way were Cindy Harder, Karen Bame, and Matt Maltrud, shown on the cover as they marched around Ashley Pond.

Bill Jack Rodgers, ISD-1, was there to capture that moment with his camera. Some of the other moments he captured are shown in a "scrapbook" beginning on page 11.

Los Alamos is a unique community in many ways. Yet, in other ways, it is just like thousands of other communities across the land. Two of these ways are its pride in our country and its unabashed enjoyment of parades and all the other events connected with a bang-up Fourth of July celebration.

TO SEE THINGS MORE CLEARLY

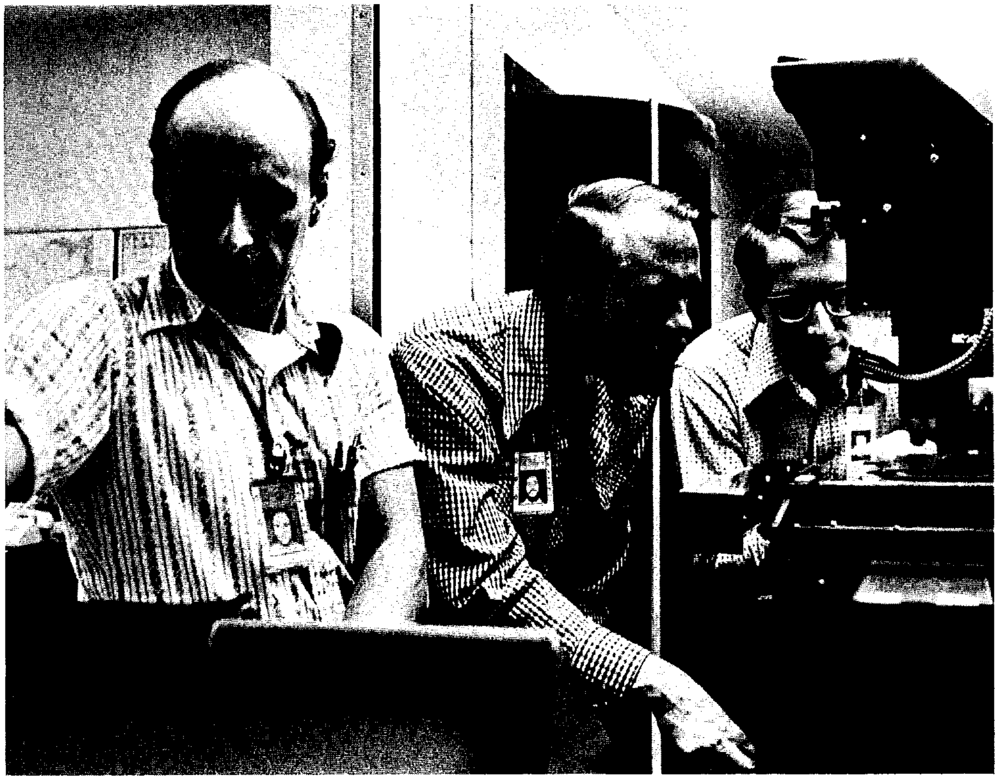


Look at the above photo from a distance and see how it suddenly gives you a new view of things. It is the computer-processed, sharpened, and enlarged left eye of the girl in the photo below. The computer translates points on the original photo into sharply defined squares of various tones, yielding an image more readable in terms of data. This photo is used for test and demonstrations; Group C-8's usual fare is less photogenic, but more interesting, scientifically speaking, as shown on the following pages.

Have you ever taken a photo at a "once-in-a-lifetime" moment, such as when your daughter blows out the candles on her first birthday cake, only to have the negative turn out so fuzzy or washed out that there was no way to make a decent print from it? If so, you know the frustration that researchers at the Los Alamos Scientific Laboratory have sometimes felt in the past when they first looked at photos they had made during experiments.

But unlike you, LASL investigators today have a possible "cure" for their "hopeless" photos. They take them to Group C-8 (image analysis) where "surgeons" take the original image apart, feed the pieces into a computer where they are altered, then put the pieces back together again to form a far more readable image than the original.

In some cases, the challenge is to bring out detail that is undetectable or, at best, only faintly and imprecisely discernible in the original



Key hardware for image enhancement or correction is a computer, being operated by Dick Bagley, C-8, left, and a scanner being set up by Dick Kruger and Mike Cannon, both C-8, right. The scanner traverses a photo line by line, measuring tones at thousands of points. This digital data is fed into the computer for alterations.

negative or print. Notable examples of this type of problem are many of the flash radiographs made by Group M-2 at LASL's PHERMEX facility during explosion experiments. The nature of flash radiography is such that areas of interest are often very flat in the resultant image. In 1970, Group C-5 (statistical services) began assisting Group M-2 in their early efforts to enhance the images; in 1974 parts of the 2 groups merged to form Group C-8. The current PHERMEX enhancement work is carried out by James Breedlove, Rollin Whitman, Howard Demuth, and Martin Lahart and still accounts for about 25 per cent of Group C-8's "business" today.

The enhancement process begins when Dick Bagley in Group C-8 sets up a photo so that it may be scanned line by line. A great number of points at regular intervals along each line are light-metered. These values become numbers that can then be used by a computer. In the computer, all the numbers, or just those numbers pertaining to areas of interest, are altered. For instance, numbers close together in value can be separated by such means as adding or subtracting a minimum or maximum density value from each, then multiplying by a constant. The new set of numbers can then be used to form a TV image or make a new photo in which areas of interest show contrast and definition, thus providing more informative images to experimenters.

"The heart of the process is in writing an algorithm that will instruct the computer to perform the mathematical operations appropriate to the problem," says Michael Cannon, C-8. And he further explains that an algorithm is a set of instructions for repetitive mathematical operations. Although written mathematically, in English a simple algorithm might read: if "a" is larger than "b," do this. If "a" is smaller than "b," do that. No human could perform the hundreds of thousands of individual alterations required even for a small photo, at least not within an acceptable time period, but computers can do it in seconds.

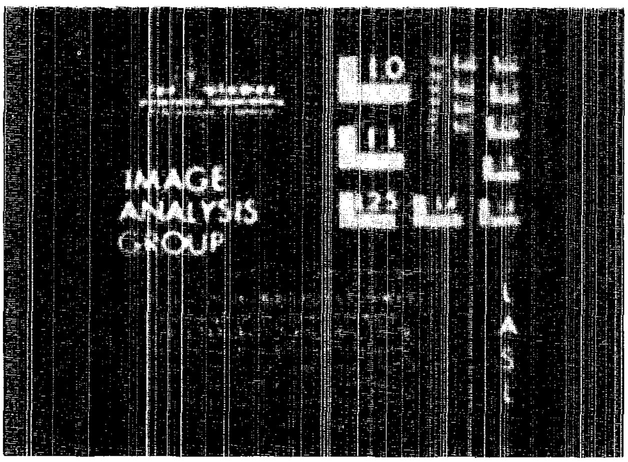
Although enhancing contrast and definition employs what would today be considered "simple" algorithms, such is not always the case for other types of "surgery" that Group C-8 is now conducting. Algorithms to make an out-of-focus photo acceptably sharp and rich in detail, for example, call for mathematics of a high order. LASL's facility for image enhancement and restoration is 1 of the 5 major facilities for this purpose in the country, and Group C-8 has been credited with many software contributions to the state of this specialized art.

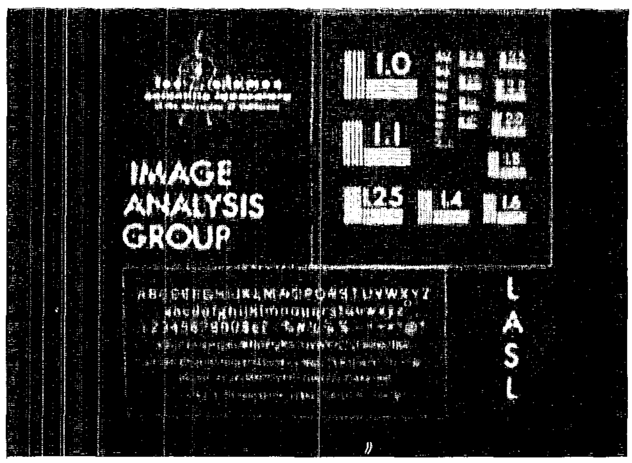
In some cases, a blurred photo is imposed upon researchers simply as a limitation inherent in the nature of the subject or the photographic technique itself. In other cases, it may, just as for an amateur photographer, be the result of camera movement or an error in

BEFORE

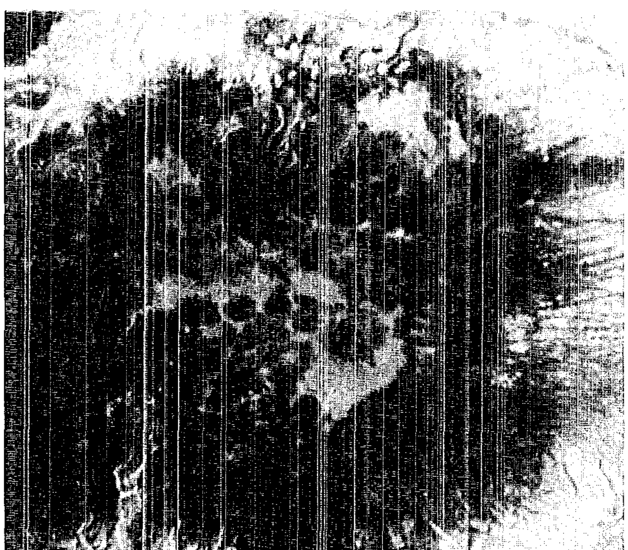
AFTER

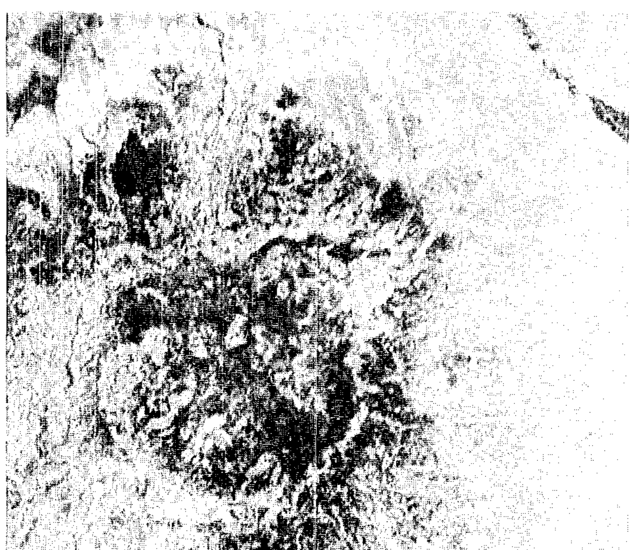
An example of enhancing an x-ray to show contrast and detail, of potential interest to orthodontists, is shown above. Enhancement in the photo at right brings out better, sharper detail both in teeth and bone structure. Below, demonstration photos show how an out-of-focus photo may be made acceptably sharp.





Certain distortions are inherent in satellite photos due to electronics, as in this photo of the Jemez Caldera near Los Alamos. Group C-8 alters the photo at left to show true perspectives in the photo at right.





setting the lens focus.

To illustrate the latter, Group C-8 deliberately blurred a photo of lettering and "test pattern" lines. Yet, by processing the photo by computer, the edges of the lettering and lines were made conspicuously sharper. "We can't restore all detail lost in a blurred photo," Cannon says, "but we can restore much of it and come up with a photo that is surprising in its sharpness and quite useful from the point of its information content."

Another type of manipulation that Group C-8 can make, usually handled by George Wecksung, is in the geometric alteration of the perspective of a photo. In effect, the computer moves some digital points to new positions to create the illusion that the photo was taken from another camera position. In other cases, distortions are inherent in the electronics of satellite scanning systems; Group C-8 makes the necessary corrections.

Some of the more recent applications of image enhancement and alteration have been in biomedicine. A single x-ray image of dental features generally cannot delineate detail of both internal tooth structure in hard material and the structure of soft surrounding gums. Don Janney, Joel Trussell, or Rosemary O'Connor can set up a program to enhance detail in both areas of interest, a capability of great potential usefulness to the oral surgeon. And Dick Kruger is involved in enhancing electron microphotos of human cells for Sam Boyer of Johns Hopkins University to show the distribution of fetal hemoglobin within cells. Hemoglobin is the oxygen-carrying substance in blood; some of it is "inherited" from the mother before birth, remains in the body throughout life, and is believed to be a carrier of genetic codes. Among the special challenges of this particular project is establishing a circular outline representing cell boundaries. On the original film there is no discernible boundary in the gray "smudge." The computer determines where the boundary should be and draws it in.

Another application of this cell-boundary detection technique supports Bryan Goldstein, T-10, in his studies of the ability of certain cells to form antibodies. Kruger receives photographic results of experiments conducted by Stella Esrig at Fairleigh Dickinson University. One series of microphotographs shows a substance called placque expanding around an antibody-forming cell. Boundaries are difficult to determine visually, but the computer draws them in, enlarging the boundaries progressively for each photo to show the placque's growth.

A similar boundary-detection technique is applicable to other tasks. For instance, small air voids in the high-explosive portion of an artillery shell can cause accidents. Conventional x-rays of shells are virtually impossible to read for these voids. The computer can detect regions containing voids and depict them quite emphatically.

And there are other methods in Group C-8's "bag of tricks." One technique that appears both sophisticated and exotic, but, comparatively speaking, is simple and straightforward, is the depiction of a black and white photo in color. Various black and white tones are assigned colors. In the finished TV display or image, the different colors create a vivid delineation of various tonal areas.

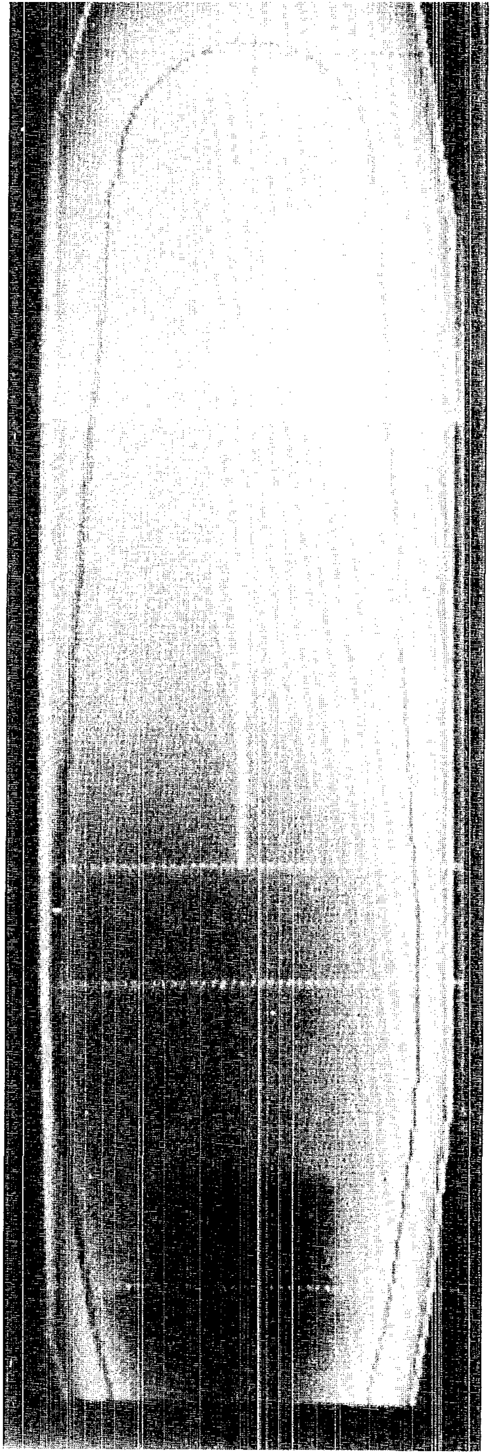
An essential part of Group C-8's operation is known by the odd but easily remembered acronym, LADIES (Los Alamos Digital Image Enhancement System) Library. Tom Alexander, Sherron Kirkpatrick, and Clarice Cox have created and catalogued many of the algorithms for processing various types of images, a resource that speeds and simplifies projects not only for Group C-8, but for all LASL groups with an interest in processing digital pictorial data.

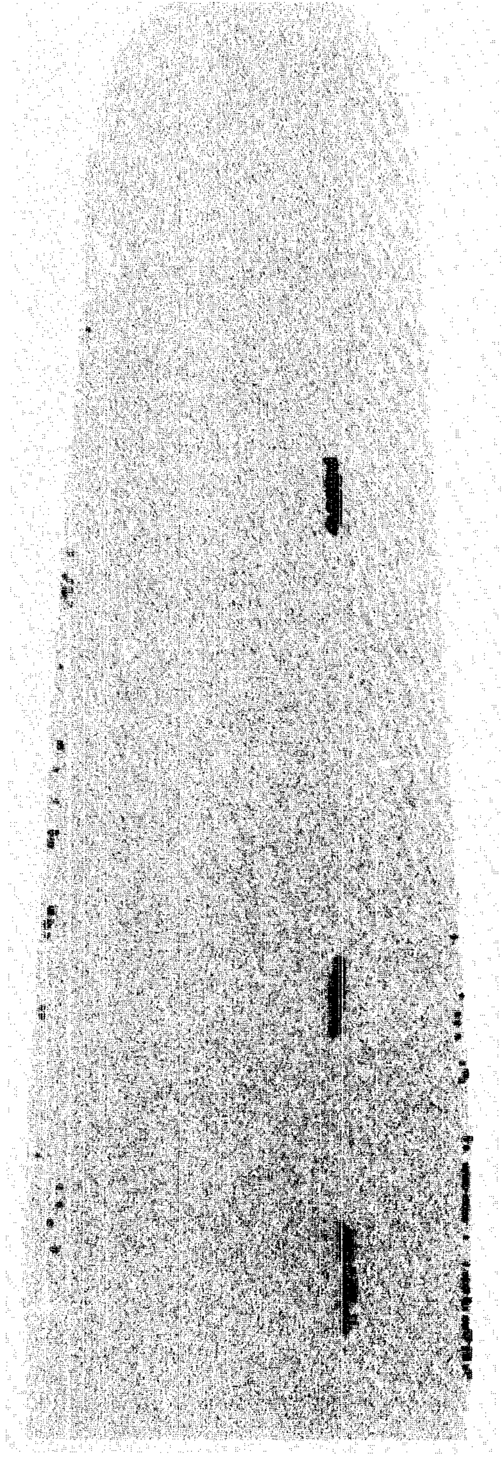
The future for computerized enhancement, restoration, and manipulation of images to discover and analyze meaningful detail seems limitless. One promising field is in satellite photography, such as by the 2 LANDSAT satellites launched by NASA to record images of the ground beneath them.

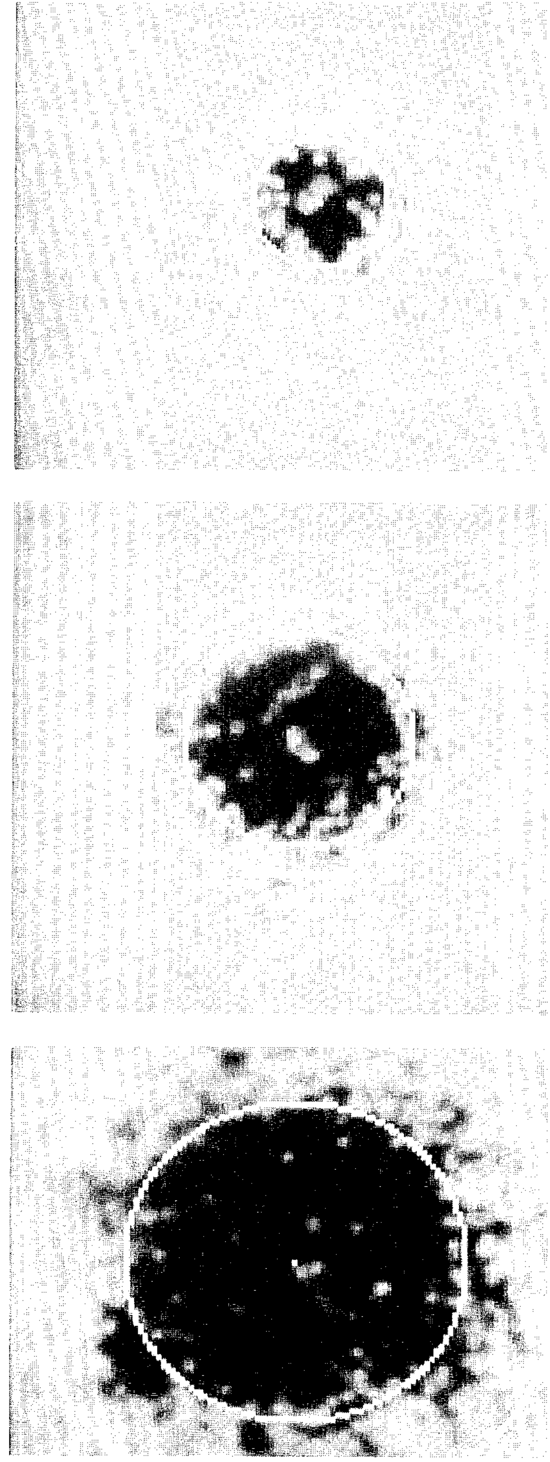
The LANDSAT orbits are set so that the rotation of the earth under the satellites brings under surveillance about 90 per cent of the earth's surface, which is recorded at the rate of 1,500 images a week. Merely handling this volume on a clerical basis, such as annotating for weather conditions, would require computerization. But the need for computerization extends far beyond this simple application. Photos are made in 2 visible and 2 invisible spectra. Each spectrum brings out meaningful detail in certain features of the terrain, such as forest and vegetation or bare rock and soil. Integrating these images requires computerized manipulation. Beyond that, the sheer volume of photos requires some method for computers to alert humans to significant patterns in photos calling for examination.

Although handling this enormous volume of data is a formidable challenge, the potential rewards are worth it. Among other things, the LANDSAT program may lead to the discovery of new mineral resources, the detection of disease in crops, and, ultimately, the prediction of food harvests on a global scale so that mankind can at least have the opportunity to plan for shortages and surpluses and act accordingly. Group C-8 is now enhancing and geometrically correcting LANDSAT images in collaboration with Dick Vogel, Q-10, in implementing a program for assessing the impact of developing energy resources, such as coal and shale deposits, for the Rocky Mountain states.

Whatever the future holds for computerized image enhancement, restoration, and analysis, the "surgeons" of Group C-8 will be involved, devising new and ever more sophisticated ways to bring out indistinct photographic data that modern investigators need to know.







Above left, a computer-processed radiograph of an artillery shell is virtually impossible to read for tiny air voids. A second processing defines void regions in the photo above center. A similar technique is useful in biomedical research, as shown in the series of photos, top to bottom, at right. An antibody-producing cell generates around it a substance that expands. The computer draws in boundaries at various stages in the substance's growth.

out-of-this-world energy for space and earth

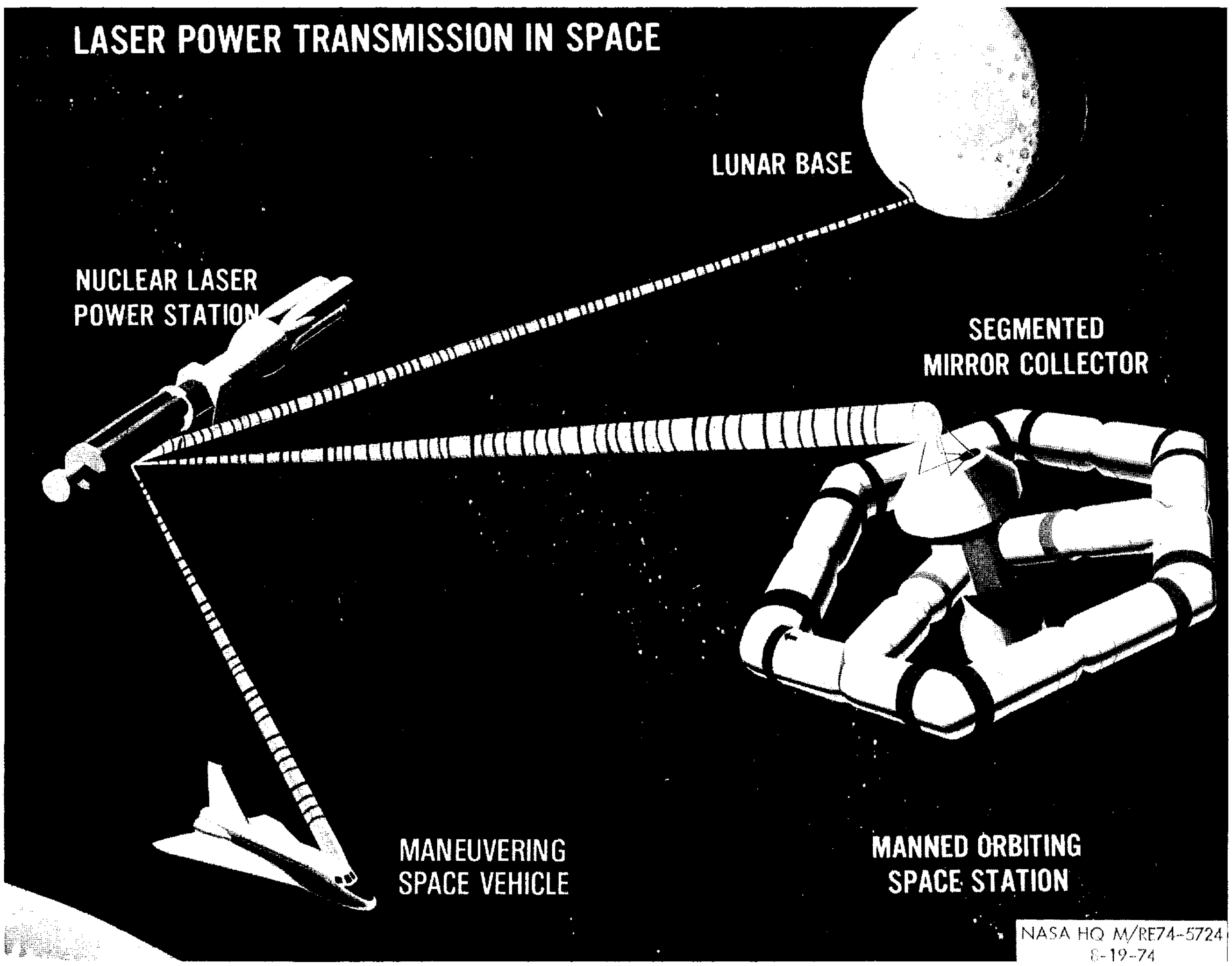
A space ship approaches an orbiting satellite and signals a command to it. Moments later, the satellite flashes an intense beam of laser light to the spaceship, giving it a massive transfusion of energy. In the background, the moon looms large enough so that a lunar base is discernible. In the colony live 5,000 or more people, their energy needs met by a highly efficient 10-megawatt reactor so compact that it occupies less than half the volume of a typical school classroom.

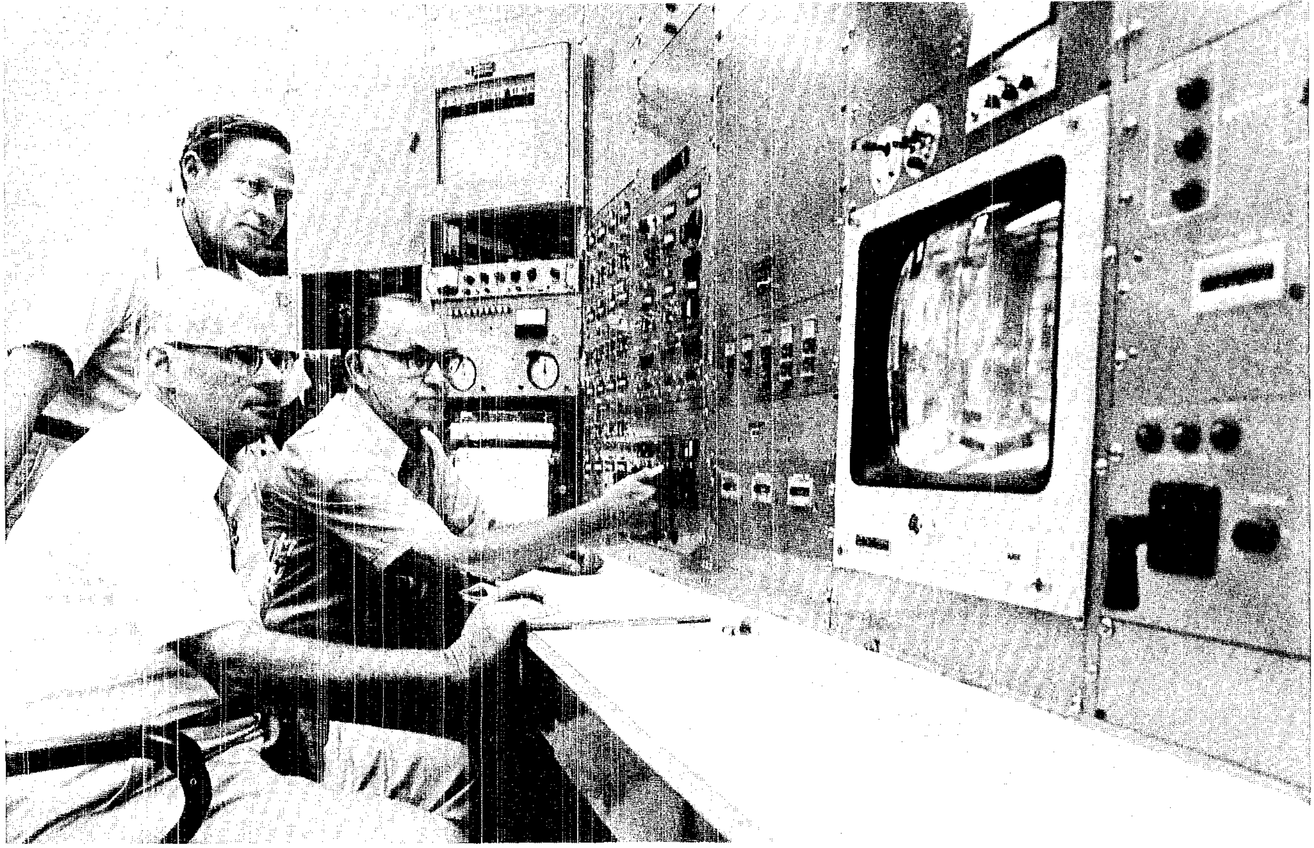
It all may sound like a scene from a *Star Trek* TV episode. Yet, to the National Aeronautics and Space Administration (NASA), at least some of the elements of the scene are realistic possibilities, which is why that agency is supporting a program for the development of gaseous-core reactors and nuclear-pumped lasers. Much of this work is being done by Group R-5, whose hardware includes some of the equipment salvaged from the defunct LASL program for nuclear propulsion in space (Project Rover).

In addition to the applications that gaseous-core reactors and nuclear-pumped lasers may find in space, NASA sees some attractive potential benefits on earth as well. Some of these might be high efficiency (due in part to high temperature operation), more easily handled fuel because it would be in a liquid or gaseous state, and substantially reduced radioactive-waste handling problems. In addition, the gaseous-core reactor could be a breeder reactor producing more fuel than it consumes.

Because commercial reactors use solid fuel, not everyone realizes that fuel for reactors can also be liquid or gaseous, as Gordon Hansen, R-5 group leader, points out. One of the world's first reactors, the Water Boiler, built at Los Alamos during World War II, operated on liquid fuel, and gaseous-core reactors have been studied by NASA as a means of rocket propulsion since the 1950's. In simplest terms, it does not matter whether uranium-235 atoms are in solid, liquid, or gaseous form so long as enough of them are assembled in a critical mass to initiate and maintain the fission process.

The first Laboratory gaseous-core reactor, engineered by Roger White and Bill Bernard and now being operated by George Jarvis, Dave Barton, and Dallas Clayton, all R-5, is a relatively simple device consisting mainly of a chamber and a static charge of gas. More sophisticated models lie ahead. Future models would incorporate a closed circulating system with subsystems for cooling and storing the gaseous





Dave Barton, R-5, seated, (left) and Gordon Hansen, R-5 group leader, standing, watch closed-circuit TV showing a gaseous-core reactor in a nearby "kiva" as George Jarvis, R-5, turns a handle which rotates a control rod in the reactor. Experiments are now being conducted with static gas; future experiments call for more sophisticated and powerful reactors with circulating systems.

fuel and removing wastes from it. Such a circulating system has been fabricated and is expected to be received at LASL later this summer.

Interestingly, in theory a system can be designed that would achieve an equilibrium in respect to long-lived radioactive wastes whose removal and disposal are problems in conventional solid-core reactors. The recycling feature of a circulating gaseous-core reactor could lead, after a period in operation, to the transmutation of these wastes to other less potent elements at a rate equal to their production in the reaction chamber.

If all this sounds simple, which it is, there are good reasons why gaseous-core reactors have not been developed for commercial purposes. The higher temperatures involved pose formidable technological problems, and the gas that would be used, enriched uranium hexafluoride, is tricky stuff. "Enriched uranium, because of its potential criticality, and fluorine, one of the most active and corrosive of elements, pose some problems in handling," says Bert Helmick, R-5 alternate group leader, in something of an understatement.

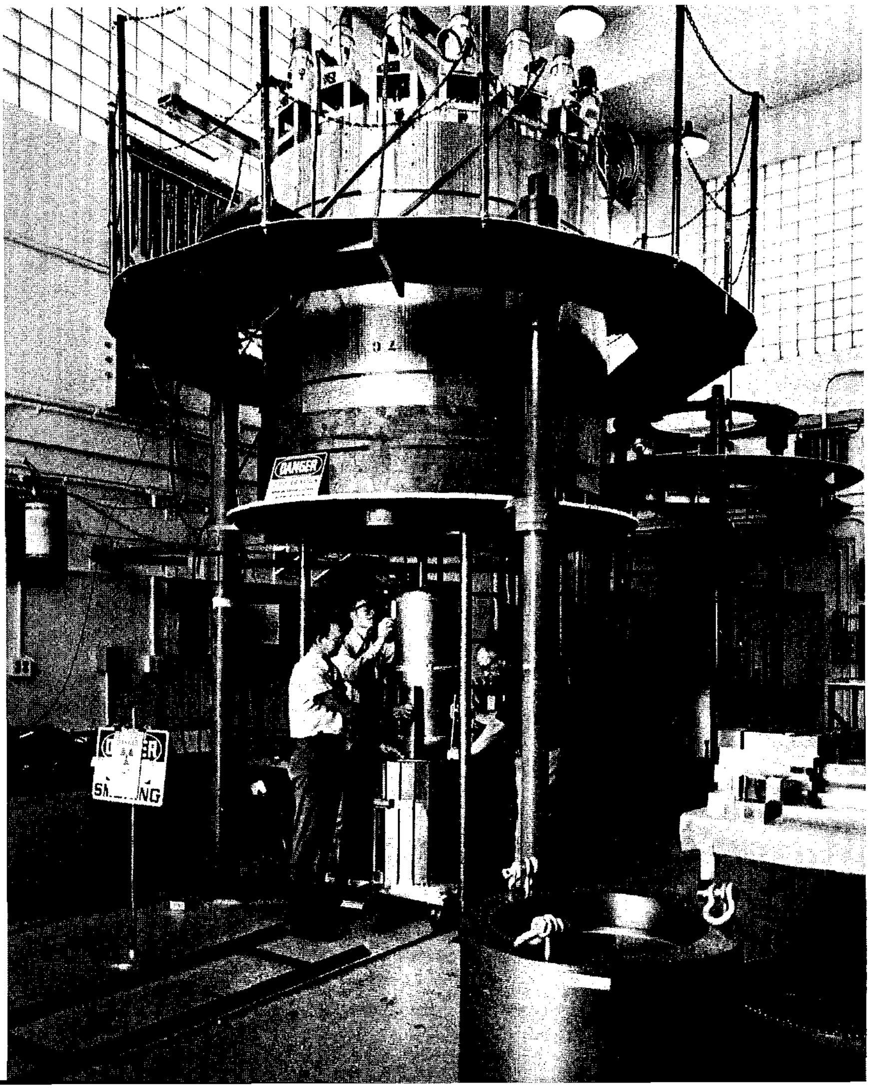
As in any reactor, there must be control rods and moderating materials near the chamber to reflect and slow down the neutrons produced by fission so that the process can be properly controlled. Much basic research must be performed, especially with materials proposed for the reactor, before a final demonstration model can be built. One major area of research involves determining whether the fuel will remain a gas for prolonged periods of operation in the chamber's high-radiation environment.

Group R-5 plans to build, over a 3-year period, a series of gaseous-core reactors, each operating at higher temperatures with greater efficiency and power. A very advanced model envisioned in NASA's program might be a reactor that does not use gas at all, scientifically speaking, but pure uranium plasma. Plasma consists of atoms from which the electron shells have been stripped by extremely high temperatures; the properties of a plasma are so different from those of a gas that physicists consider plasma to be a fourth state of matter. Its use in a reactor may result in an efficiency of 65 per cent or more. The temperature of plasma is so great that a cool buffer gas, such as argon, would be injected to "line" the chamber walls to protect them from the intense heat.

Fission Plus Laser Equal Power

Since lasers were invented in 1960, the list of lasing media has expanded tremendously, but methods for pumping lasers have involved either photons or electrons. Pumping is the act of applying energy to the lasing medium in order to jar electrons to new orbits

Above, Luther Lowry (foreground) and Roger White, both R-5, move a canister of gaseous fuel under an experimental reactor. Below, the canister is in position to be raised into the reactor, whose moderating materials and control rods in its walls will regulate fission.



(the atoms or molecules are then said to be in an excited state). When the electrons snap back to their normal orbits, either spontaneously or by stimulation, they release energy as photons, which constitute the laser light.

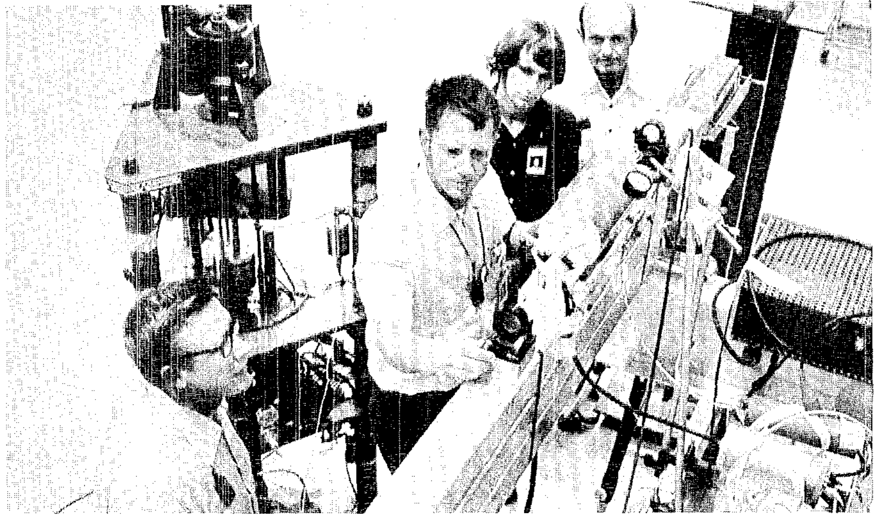
In 1972, Helmick, Tom Wimett, and Bob Wagner, all R-5, believed that lasers could be pumped in another way—by fission fragments—and conducted some experiments that seemed to support this hypothesis. In 1975, using LASL's Godiva fast-burst reactor as the energy source and a helium-xenon gas laser, they produced true lasing. Neutrons from the reactor interacted with uranium foil lining the laser cavity to produce fission fragments that in turn accomplished the pumping process in the gas. Analysis showed that the laser light produced had a 3-5-micrometer wavelength (in the infrared spectrum).

Today, the experiments go on at Pajarito Site as the Godiva reactor (so named because it is "bare," i.e., without shielding) is used by Paul Bird, Chuck Mansfield, both R-5, Helmick, Wimett, and Wagner to produce very short but intense bursts of neutrons to pump glass, liquid, and gas lasers; the latter are being tested with a number of gas mixtures. The laser light produced is reflected by 4 mirrors through a small labyrinth of cement-block walls (to provide shielding) into a room where the lasing effect is recorded.

Although valuable as a research technique, this method of laser pumping is not notably efficient. Only a small fraction of the neutrons emitted by the nearby reactor enter into the lasing process, and there are further losses in the various interactions. What really excites Group R-5 is an as yet untried concept that would produce unprecedented efficiency: the mixture of both the fissioning gas and lasing gas in one stream. Now, with all of the actions and interactions bottled up, so to speak, few of the neutrons and fission fragments are "wasted";

most of their energy is translated to laser light.

It is this sort of device that leads to the *Star Trek* type of speculation. As Helmick points out, in space, with no atmosphere to impede or scatter its energy, laser light, with its unique characteristic of remaining in a narrow beam for *tremendous* distances, would be a nearly perfect, almost no-loss means of transmission. "All" that would remain would be to develop means to receive the beam and transform it to another form of usable energy --but that's another story.



Above, Bert Helmick, R-5 alternate leader, Chuck Mansfield, R-5, George Radda, summer student, and Paul Bird, R-5, prepare a laser cavity for an experiment. The Godiva fast-burst reactor in back of them will later release neutrons that will react with the cavity lining to produce fission fragments to pump the laser.

Meanwhile, Back on Earth

If there is excitement in nuclear-laser systems for space applications, just as exciting to Group R-5 are the advantages gaseous-core reactors could provide in nuclear-power generation on earth.

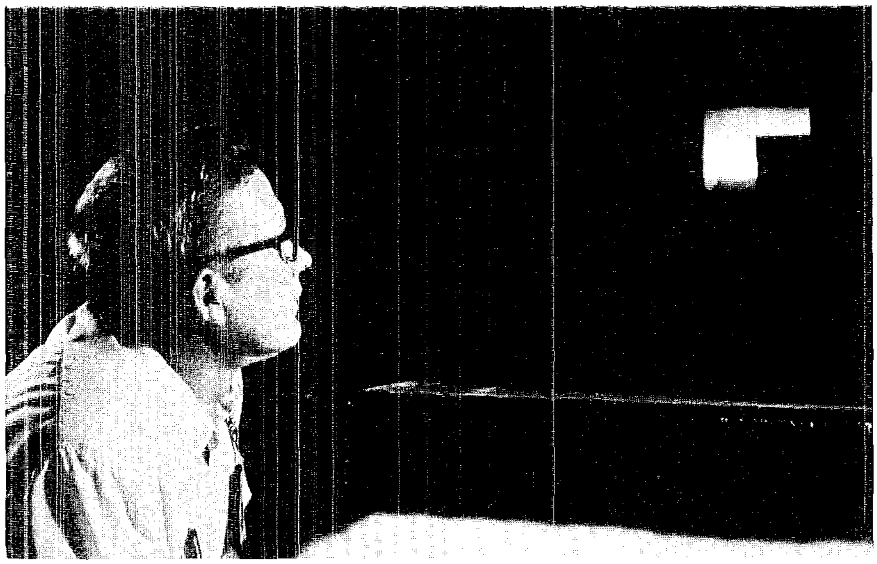
Of some concern to critics of present-day solid-core reactors is the possibility, remote that it may be, of a meltdown with a subsequent release of radioactivity. Helmick feels that, with proper attention to design, a gas reactor could minimize the effects of such an accident.

Because the size of the reaction chamber and the amount of fuel required would be small, gaseous-core reactors may be suitable for small power-generating stations or for industrial processes where the higher temperatures may also be advantageous.

And finally, the potential sub*stantial reduction* of waste in the system (with a corresponding reduction in waste disposal problems) and the possibility of breeding more fuel to extend our national fissionable fuel resources are intriguing.

If all this seems like a dream in answer to some of the objections *raised against nuclear power*, it is. But it is a dream grounded solidly enough in fact to warrant major NASA support.

And if anyone can make the dream come true, the men of Group R-5 feel they're just the ones who can do it.



Above, Helmick checks an alignment-laser beam entering the shielded diagnostic room and, at right, Radda and Mansfield adjust mirrors to align its optical path.

short subjects

Honors: **Harold Agnew,** Director, has been appointed by Governor Jerry Apodaca to serve as state chairman of Action for Education, a statewide effort to promote support of New Mexico's colleges and universities through a $25 million bond issue to be voted on in November, 1976. Agnew will be appointing committees, composed of alumni and friends of the universities, to work for the bond issue in each county of the state.

Morton M. Kligerman, assistant director for radiation therapy and director of the University of New Mexico Cancer Research and Treatment Center, has been elected first vice president and a member of the executive committee for the American Radium Society.

Richard J. Bohl, L-DO, will serve as a member of the National Bureau of Standards' speakers bureau on metric information.

Evan Campbell, H-5 alternate group leader, has been elected to a one-year term as president of the American Industrial Hygiene Association.

William Briscoe, E-DOR, has received the Outstanding Engineer Award of the Los Alamos Section of the Institute of Electrical and Electronic Engineers.

An Applied Photochemistry (AP) Division was formed at LASL on July 1, with **C. Paul Robinson** as division leader and **Reed J. Jensen,** alternate division leader.

The division will do laser isotope separation research that previously was done in the Laboratory's Laser Research and Technology (L) Division.

L-Division will continue laser fusion research with emphasis on military applications and energy production. **Keith Boyer** will continue as division leader and will assume a new post as LASL assistant director for advanced technologies.

Arthur Sayer, retired and formerly J-14, received a 30-year service pin. His name was inadvertently omitted from a list of service pin recipients furnished to **The Atom.**

Many of the pioneers of computer science attended a five-day international research conference at LASL in June on the history of computing. The conference, first of its kind, was jointly sponsored by the National Science Foundation and LASL. The primary purpose of the conference was to record as "living history" discussions among the pioneers in the field of electronic computing.

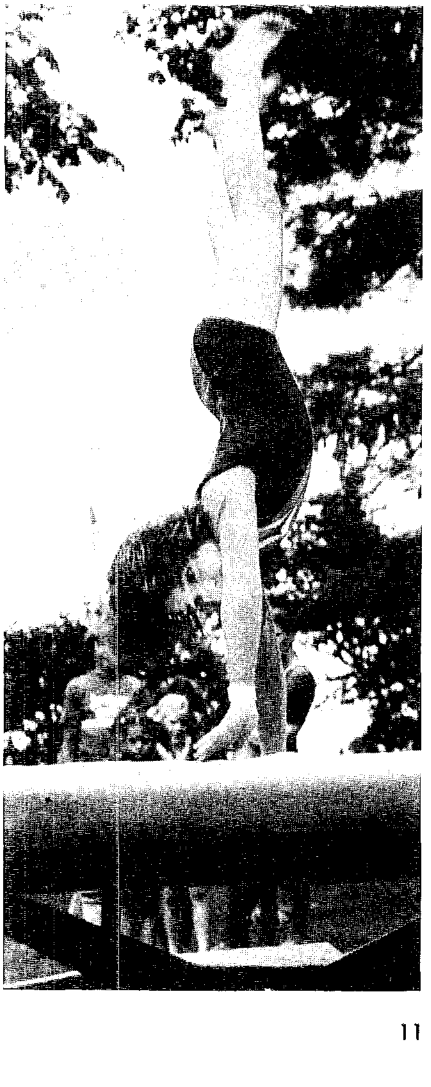
Retirements: **Jesse Clark,** P-9, technician; **William Scott,** SD-5, laboratory machinist; **Milo Smith,** SD-5, laboratory machinist; **John Carmichael,** CMB-11, special process technician; **Anna Fojtik,** H-DO, property representative; **Glen Barber,** J-12, mechanical technician; **Neva Roberson,** PER-6, alternate group leader; **Donald Nuckolls,** CMB-6, technologist; **John Stahl,** CMB-11, senior designer; **Glenn Vogt,** ENG-4, area coordinator; **William Campbell,** H-5, chemical technician; **Filmore Criss,** CMB-3, staff member; **John Schulte,** CMB-14, staff member; **Morris Milligan,** H-5, staff member; **George Hanawalt,** E-2, electronics technician; **Melvin Berrett,** ENG-4, service specialist mechanic; **Paul Flynn,** H-2, staff member and alternate group leader; **Robert Gibney,** CMB-8, staff member; **Allen Hasty,** CMB-AP, administrative supervisor; **Clement Meyer,** CMB-1, chemical technician; **Wendell Biggers,** J-DOT, staff member; **Robert Holm,** L-9, electronics technician; **Ramon Martinez,** CMB-9, senior foundry technician; **Claude Edwards,** SD-5, development machinist.

Deaths: **Dorsey Dunagan,** CNC-11, technician; **Alfonso Le Roy Martinez,** SP-3, storesman.

From ERDA: **Donald Kerr,** Q-Division alternate leader, has been named deputy manager, Nevada Operations Office, and is expected to begin his new job in August. Kerr has been with LASL since 1966 and assumed the alternate division leader post in 1975.

George Baker, Jr., T-11, will spend a year's leave of absence, beginning this fall, working at the French Atomic Energy Commission's Saclay Laboratory near Paris. He will work with members of the Theoretical Physics Department on problems of materials theory and scattering physics and on special techniques of mathematical approximation theory.

Jenine Slocomb and Susan Wampler enjoy the sun, the grass and the moment—our country's 200th birthday. An unidentified "pilgrim" has just finished a hot dog and has a soft drink with which to wash it down as he observes activities at Ashley Pond. Lynn Thomas of Los Alamos School of Gymnastics demonstrates her athletic ability for onlookers during the July 4 festivities.



A Bicentennial Scrapbook

Birthday parties are fun. Almost any child will tell you it's so.

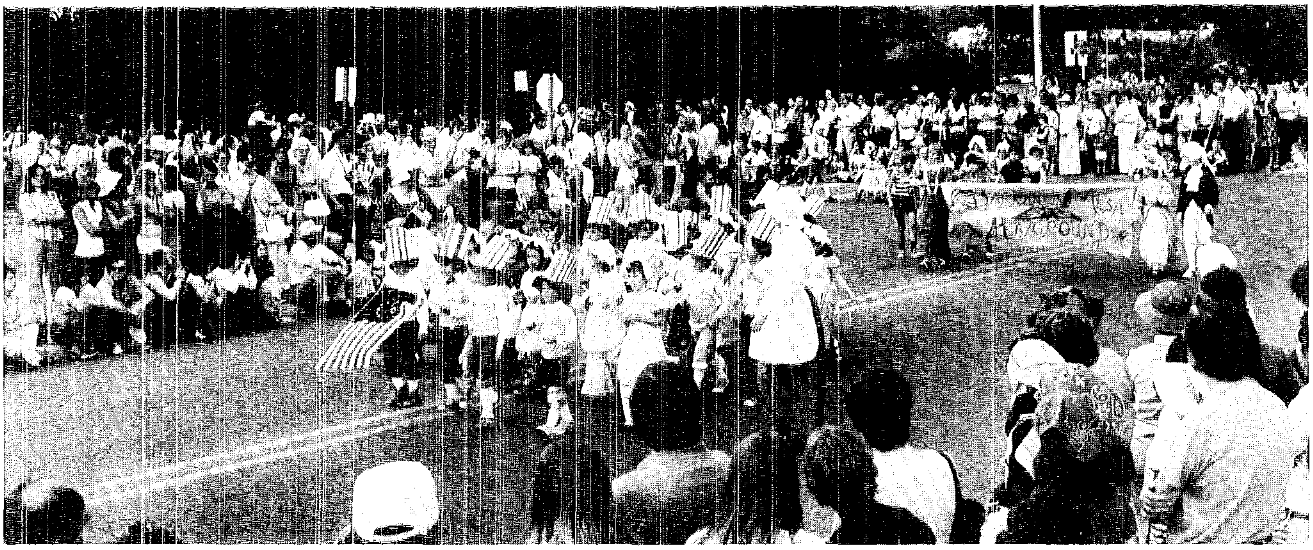
But when the birthday is America's 200th, the festive spirit is in just about everyone.

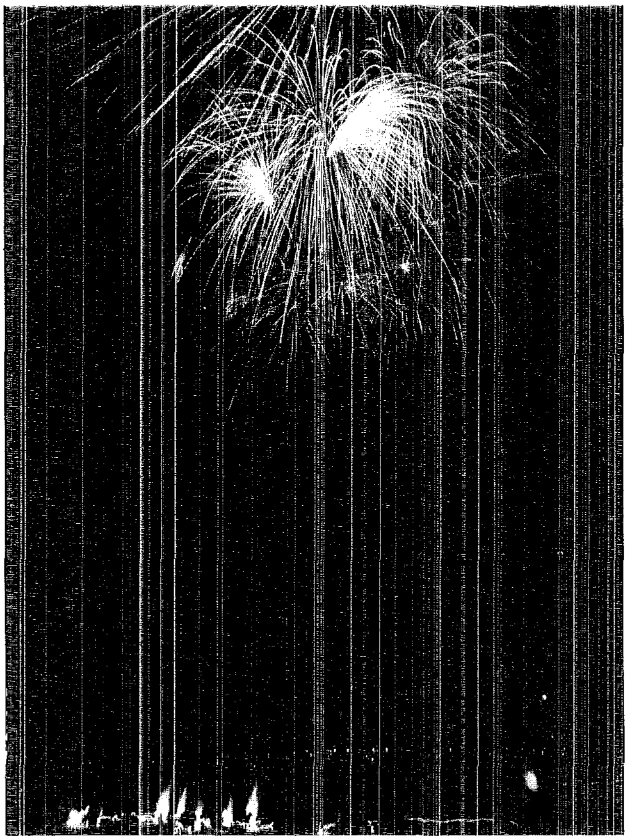
Los Alamos area residents enjoyed an "old-fashioned" July 4th with parades, square dances, boat rides, picnics at Ashley Pond, flag raisings and dedications, a fair, and, of course, fireworks.

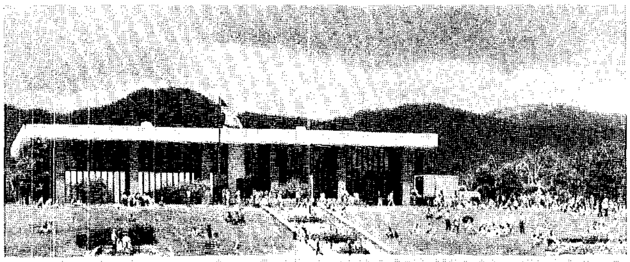
There was music, and there were community projects for young and old. There were night events and day events, with lots of time in between to daydream and relax or run and play.

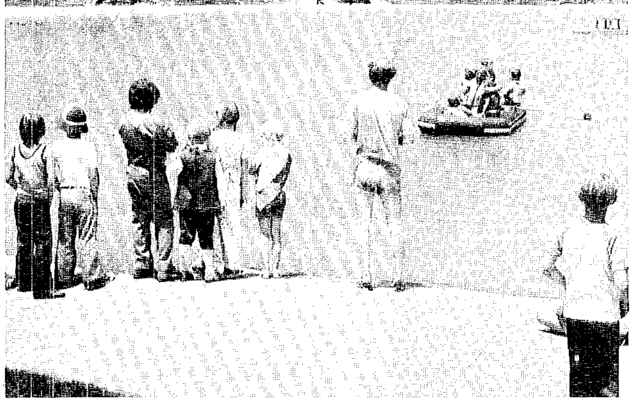
It was a fun party, an event-filled celebration, as the photos on this page and on the following two pages (taken by ISD-1 photographer Bill Jack Rodgers) will show.

Jan McDonald directed the Los Alamos High School Band in concert for the listening pleasure of celebrants at Ashley Pond, above left. The bicentennial seal was attached to a wall at Fuller Lodge, above right, and new and old dress styles were modeled by Amanda Ford and Sean Manning, right. Picnics at the pond were popular on the Fourth, below, as was the arts and crafts fair, left, where Janice Muir shows a piece of clay ware to Anna Brandell.









Hundreds of children participated in a parade to salute America's birthday, top, and local Boy Scouts offered boat rides on Ashley Pond, right center. The Mountain Mixers square dance group put on a show on the mall at the post office, right, and fireworks lighted the night sky over Los Alamos, above.

LASL Group Studies Sun

By Johnnie S. Martinez

Two long years of preparation for 200 seconds of scientific observation time are far from enticing odds for anyone tempted to get into the solar exploration work being conducted by members of the Los Alamos Scientific Laboratory's P-4 (Space Physics) group.

The odds are particularly unattractive when one realizes those 200 seconds are dependent upon the good behavior of a cantankerous sounding-rocket system. These, however, are the circumstances faced by Richard Blake and his colleagues as they accumulate their precious bits of information about earth's life-giving star.

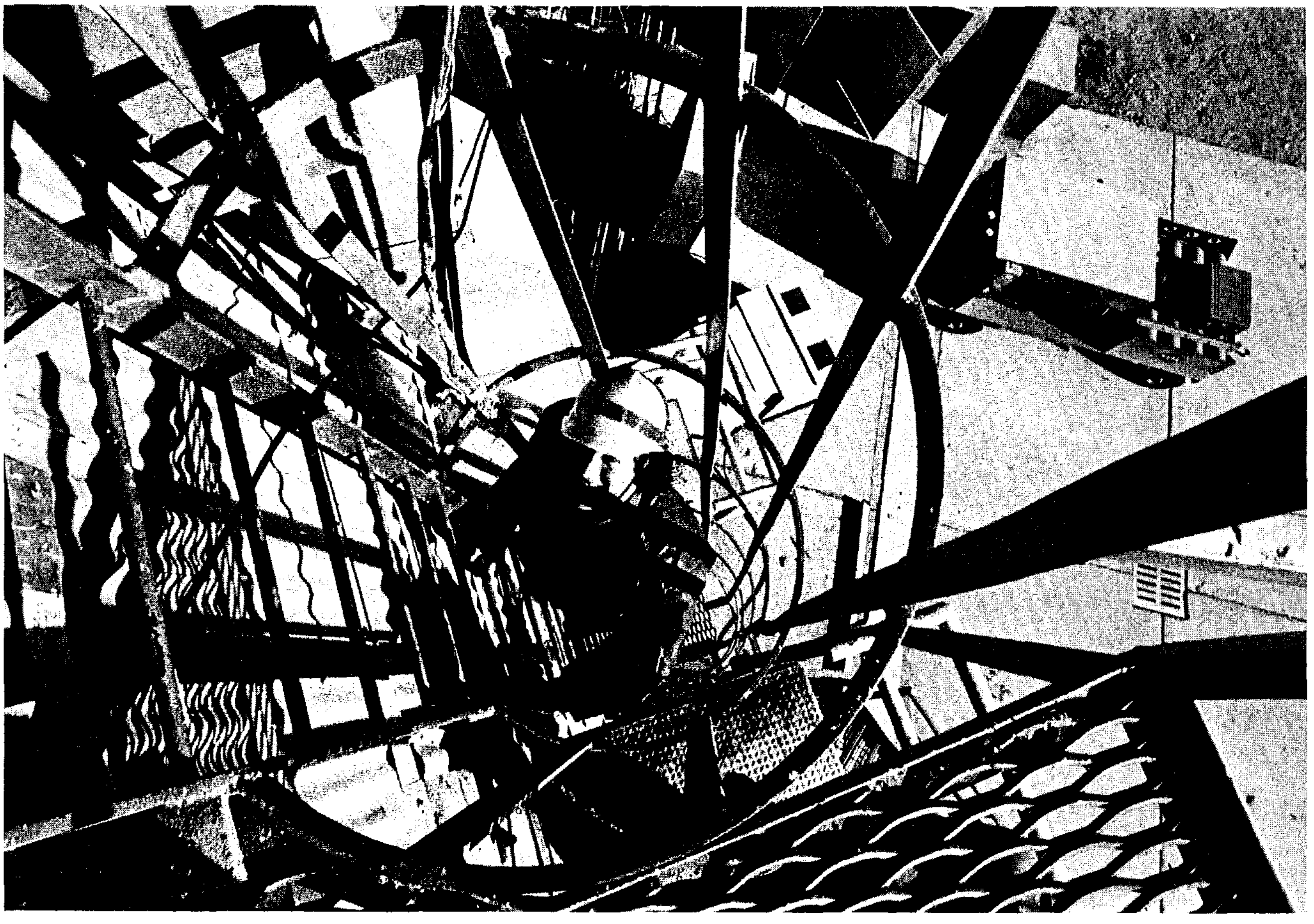
The goal is an increased knowledge and understanding of the sun —at once a source of energy and potential problem for the effect it can have on the earth's environment. The means used to obtain this knowledge border on the incredible, considering the time spent in preparing for a rocket flight that can provide only seconds of observation time and also stands a very good chance of failing entirely for reasons usually beyond control of the experimenters.

Specifically, the P-4 team is concentrating on studies of the solar activity cycle, origin of the solar chromosphere and corona, the solar wind, the abundances of various elements in the solar atmosphere and wind, and the relations of all these phenomena to the sun's convection layer and magnetic field patterns.

Part of the team, including Richard Blake, Anthony Burek, Dwight Barrus, Edward Fenimore, and James Bergey, is using rocket flights and, if the rare opportunity presents itself, will use satellite experiments to measure solar x rays and extreme ultraviolet radiation that together carry most of the available information about the corona and high chromosphere.

According to Blake, many pieces of evidence have come together that show how small changes in total solar radiation or its spectral dis-

Getting enough exercise was no problem for the LASL researchers while at the White Sands Missile Range. The myriad of tests, checks, double-checks, and adjustments required before a rocket launch kept Richard Blake and his colleagues clambering up and down the launch tower.



tribution can produce large changes in earth's environment. As one example, he reports that the total solar radiation need only change by a few per cent to cause a significant shift in the earth's global climate pattern.

To understand solar phenomena that are related to such potential "small changes," Blake and his crew have undertaken a high-resolution solar x-ray study program under an Energy Research and Development Administration grant from the National Aeronautics and Space Administration.

Lifting the various spectrometers, detectors, collimators, and cameras needed to make these high-resolution measurements above as much of the earth's atmosphere as possible is a primary requirement of the study.

Because of the scarcity of opportunities to place these experiments aboard long-range orbiting satellites, the P-4 team has been forced to rely upon short-duration, sounding-rocket flights.

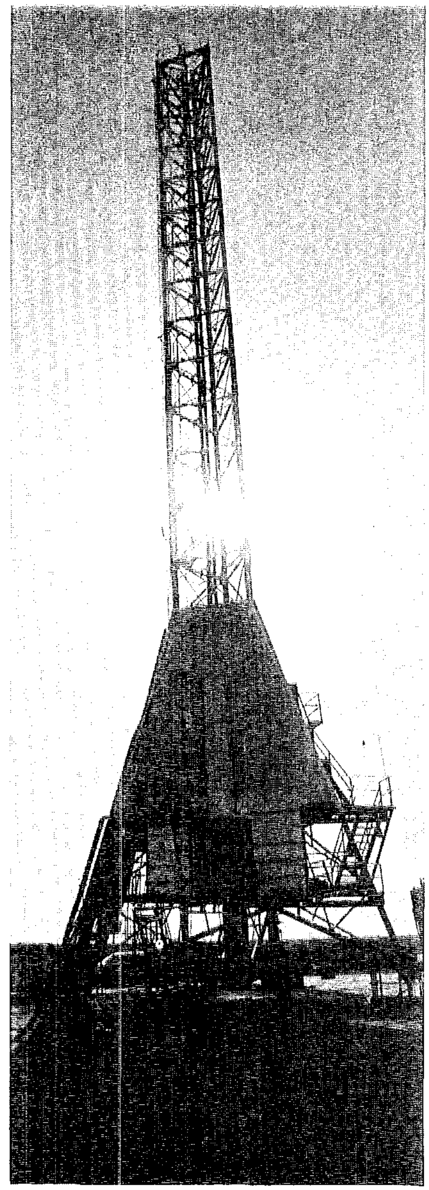
Two of these rockets have already been launched, and a third is being prepared for flight in February 1977 from the White Sands Missile Range in Southern New Mexico.

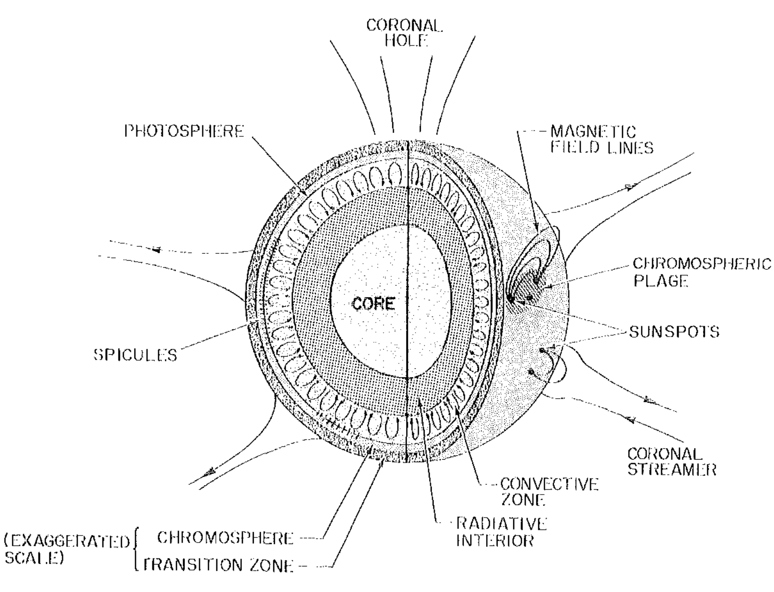
The decision to launch an experiment and instrument package which may have been 2 years in the creating isn't made lightly by Blake and his people. Once the instrumental payload has been placed in the nose cone of a sounding rocket at the missile range, a waiting period follows during which sunspot activity is watched closely.

When a suitable sunspot region has been detected, the researchers have only a few days (under present solar conditions) in which to make their decision to fly the experiment before the sunspot region either dissipates or travels to the opposite side of the sun.

Among the factors that can complicate the rocket flight is the fact that a sounding rocket, unlike a guided missile, cannot be controlled in powered flight from the ground once it's launched. High winds at the launch site that could push the rocket off course occasionally last long enough to postpone a flight until sunspot activity has disappeared. Worse, wind encountered by a rocket after launching can drive the vehicle off course and force missile range officials to destroy the rocket and its payload.

Only when optimum weather conditions are present, the instrument package checked and double-checked, the various mechanical systems within the rocket and





The cross-sectional view of the sun, left, illustrates the present concept of solar structure. Radiation generated by thermonuclear processes in the core streams outward until, near the surface, it merges with bubbling convection cells that assist in transferring energy outward. Bubbles overshooting the thin photosphere are in part responsible for the chromosphere, transition region, and corona—all of which actually merge in a cauldron of hot gases and magnetic fields. By utilizing a launch tower, shown above, the rocket can be turned and aimed to compensate for the wind, which menaces rocket launches at White Sands Missile Range.

its booster okayed, and the entire assembly is "pointed" in the right direction can the rocket be launched.

Unlike the almost leisurely rate at which a large, manned rocket appears to gain altitude, an Aerobee sounding-rocket and the Nike booster to which it is attached will explode to life and scream up into the atmosphere almost faster than the eye can follow.

Within 5 to 10 seconds, the Nike booster will have pushed the missile out of sight and hearing range. At an altitude of 5 miles (8 kilometers), the Aerobee rocket, which burns simultaneously with the Nike, will advance away from the now-exhausted booster that will fall back to earth within the missile range. One hundred seconds from launch, the Aerobee and its payload will have been thrust to an altitude of 75 miles (120 kilometers) and observations of solar x-ray spectra can commence.

For a grand total of 200 seconds, the payload's electronic attention will be focused on the sunspot region and measurements can be made of the x rays being emitted by the boiling storm just above the surface of the sun.

These high resolution spectral studies of x-ray emissions have been designed to reveal information about the ion temperature and electron temperatures and densities of earth's nearest star. According to P-4 researchers, better and better resolution is the name of the game in obtaining this information, and additional experiments that include the recording of spectroheliograms or images of the sun in the spectral transmission lines of neon 10, silicon 13, and iron 17 are being planned for the February 1977 flight.

The P-4 researchers have had their share of problems with the program, which is understandable considering the many difficult requirements of a successful rocket flight.

The first flight, in October 1974, failed to bring back any data because of difficulties with the rocket's guidance system.

The most recent flight, that of March 1976, proceeded flawlessly. The payload had parachuted safely back to earth but then was dropped about 20 feet to the desert floor from the Army recovery helicopter.

Like nervous athletes waiting in a locker room to take the field, LASL's P-4 experimenters and their Solar Pointed Aerobee Rocket Control System (SPARCS) supporters from the National Aeronautics and Space Administration go over plans, make final adjustments, joke, pace the floor, and otherwise wait for the moment that will determine the success or failure of 2 years' work. From left: Ed Fenimore of LASL converses with SPARCS mission chief Jim Van Ess (seated). While SPARCS instrumentation engineer Hugh Dee paces, Richard Blake, Tony Burek, and James Bergey (all LASL P-4) observe the preparations.

Enthusiasm and belief in the importance of the difficult-to-attain information appears to be the key to the P-4 team's ability to bear up under these odds.

"Solar processes," Blake explains, "are linked together by the nature of the sun's structure from deep interior to the outer atmosphere. Earth's climate and environment, extending from surface phenomena through the atmosphere and on into the ionosphere and magnetosphere, are *in turn determined* by the evolution of earth and sun as an interacting system."

"Solar radiation produces and controls our natural environment, which has undergone drastic change over geological time and is susceptible to short-term modification, as we have come to realize in recent years," Blake says. "Therefore, solar research must become part of our national priorities, not only to harness solar radiation for conversion to useful power but also to understand solar processes and how they influence solar-terrestrial relations."

Blake believes the key to arriving at this understanding is in the solar x rays and extreme ultraviolet radiation he and his colleagues are studying.

Radiation emitted as visible light from the sun's surface, he says, starts out as x radiation deep in the sun's core where the temperature is millions of degrees. There, energy is liberated as the by-product of thermonuclear reactions by which the plentiful hydrogen is converted into helium and a small amount of helium is converted further into heavier elements.

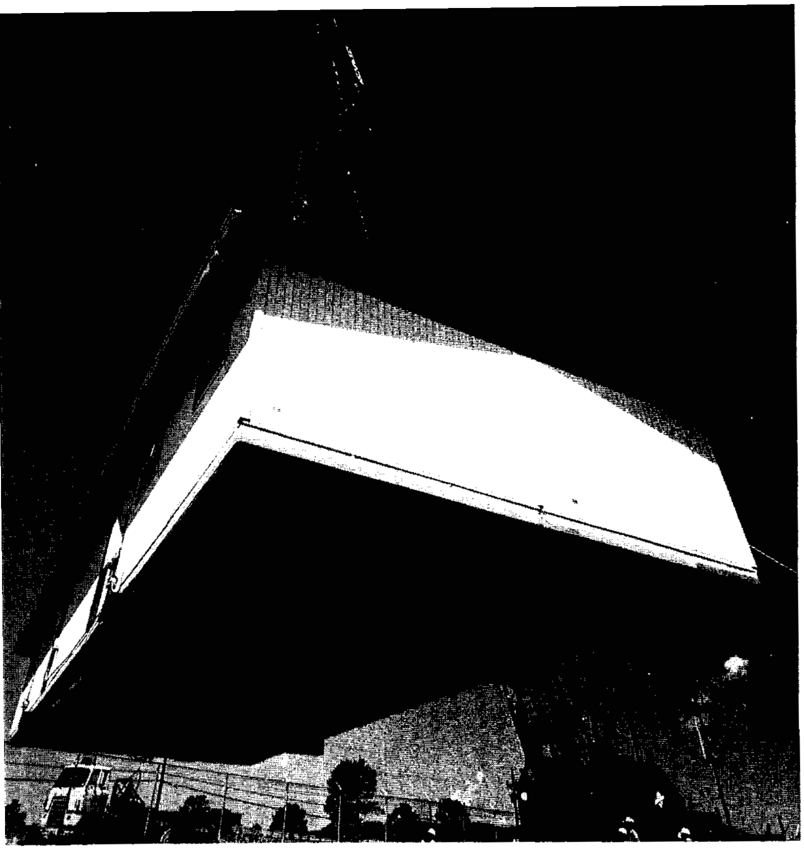
Blake says theoretical models of the sun have led us to believe this process will go on in a practically constant manner for several billion years, generating radiation of high energy (short wavelength) that gradually is degraded to lower energy as it diffuses out toward the surface, eventually to be released as visible light into space.

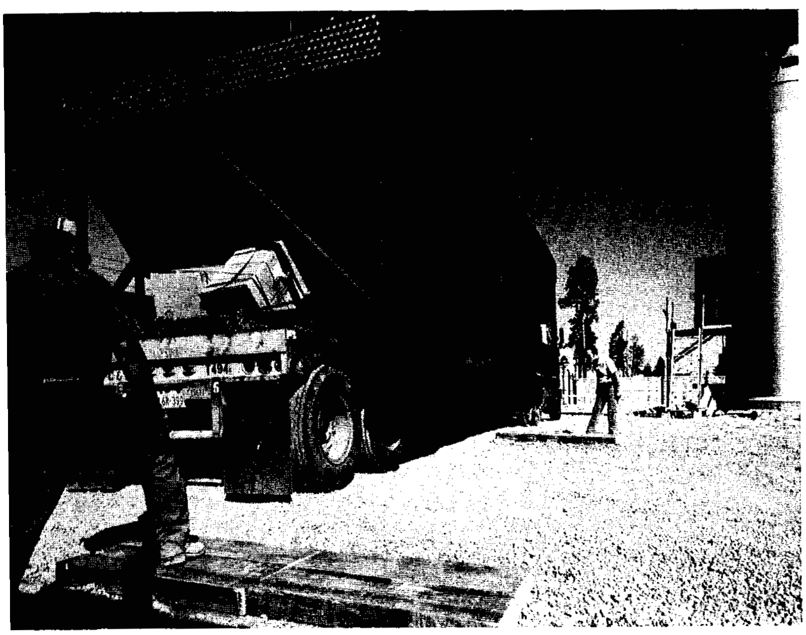
A variety of solar phenomena give rise to other conditions such as the violent storms or "solar flares" which emit into space enormous quantities of high-energy radiation and particles.

This radiation causes sudden changes in the earth's ionosphere and immediate disruption of shortwave radio communications, while the particles cause sudden changes in the magnetosphere and radiation belts as well as auroral storms.

There are many more interactions between sun and earth than those mentioned above but, according to Blake, "it is important to realize that we don't have to decipher every minute detail of every solar and terrestrial phenomenon in order to meet national goals of energy production and environmental protection. What scientists must do is accumulate in a coherent way enough knowledge of solar and terrestrial processes to permit recognition of what is essential to our goals."

After years of preparation for an experiment, the time arrives when all is ready and the researchers can do nothing more but leave the launch tower and enter the "blockhouse," or launch control building, for the countdown. Within minutes, the silent launch pad will shake with the roar of an Aerobee rocket and Nike booster pushing their payload toward the sun.





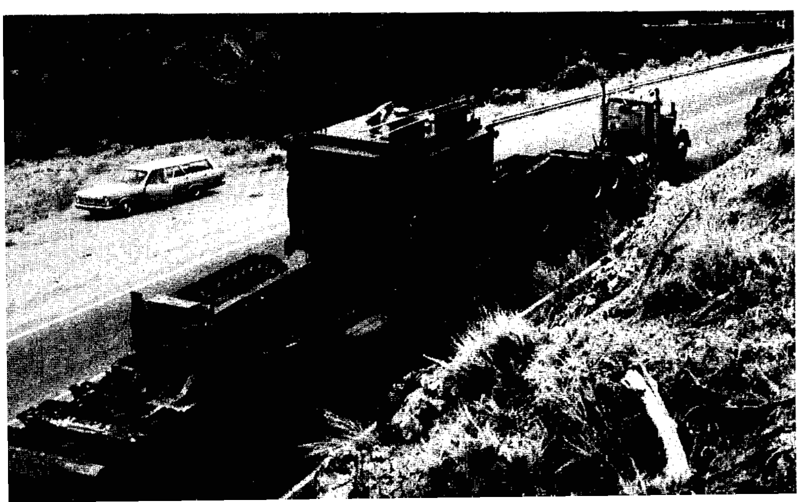


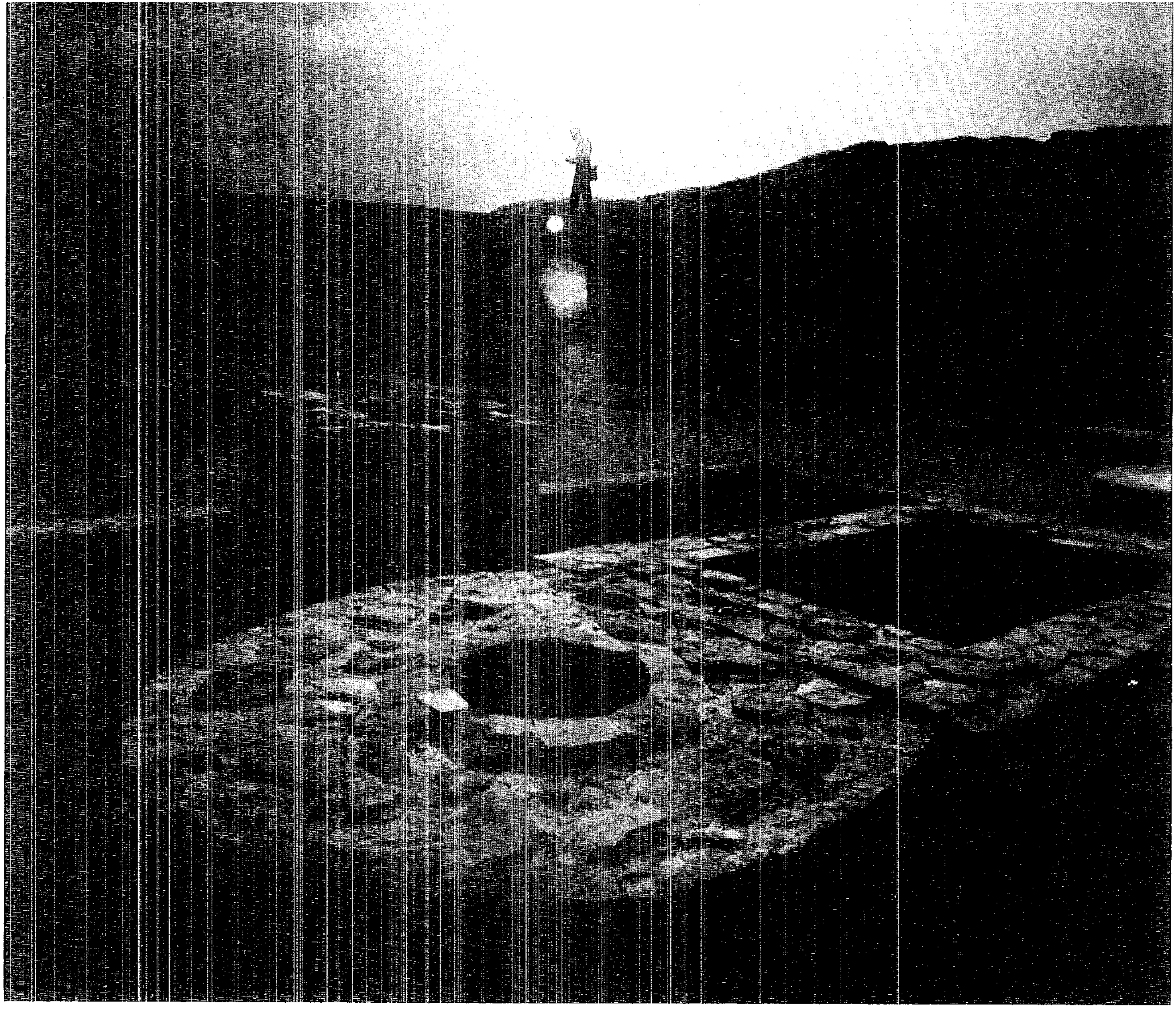
Photo Shorts

Big things were on the move around Los Alamos in recent months. At top left, a modular office from TA-55 is lowered to a new site at TA-46. Instead of disassembling the 2 sections and reassembling at the new site, the "whole kit and kaboodle" was moved on a special strongback trailer, saving an estimated $8,785 with even greater savings anticipated for 5 other similar buildings scheduled for relocation.

At center left, 1 of 2 sections of a heat exchanger, weighing 24 tons, arrives at the Fenton Hill geothermal site in early June. A piping system is now being constructed to which the heat exchanger will be connected late this year or early next year for heat-output and other measurements.

At bottom left, a 62-ton power supply, which had earlier arrived in Oakland, Calif., via barge from Kwajalein Island, neared the end of a 1-week overland journey as it approached Los Alamos and its ultimate "home" at the Laboratory's Intense Neutron Source now under construction (*The Atom*, May-June 1976).

Smoke from a forest fire in June in the Jemez Mountains floats over the San Idlefonso area. The fire, believed to have been started by humans, came within 2 to 3 miles of the LASL Geothermal Project near Fenton Hill, but a change in wind direction prevented the fire's advance to the site. Several thousand acres were burned by the flames, driven by strong winds.



The Kiva Computers of Chaco Canyon

Some 100 miles west of Los Alamos lie what many say are the most impressive and enigmatic pre-Columbian ruins in North America: Chaco Canyon. Because of their proximity, their archaeological importance, their mystique, and their excellent U.S. Park Service camping facilities, the ruins have long been popular for weekend and vacation visits by Los Alamos Scientific Laboratory families.

Most visitors are convinced that the past inhabitants, at least during the peak of Chacoan civilization (circa A.D. 1100), were much more than primitive food gatherers and crude farmers. The canyon floor shows traces of an extensive bygone irrigation system. There are a dozen principal ruins and hundreds of smaller ones, and the canyon is believed to have had a peak population of 10,000 or more. The fine masonry work shown in several pueblos, most notably Pueblo Bonito, a 4-story apartment-town that may have accommodated 1,800 people, indicates that many of the buildings were the products of a culturally advanced people.

But much more is not known about the Chacoans than is known. Mysteries include why roads 30 feet wide and straight as an arrow extended up to 65 miles from the canyon, why so few human remains have been found, and why the inhabitants abruptly abandoned such an apparent "Garden of Eden" in the late 1100's.

Most LASL employees visiting the ruins ask these and many other questions but, having other interests, do not themselves delve for answers. An exception is Jim Morgan, CMB-5 metallurgical engineer, who has pursued astronomy and archaeology avocationally since his school days in Kentucky. Since joining LASL in 1958, Morgan has been using much of his free time to learn all he can about both prehistoric and modern Pueblo Indian life. His investigations have included reading and mathematical work at home, interviews with governors of Indian pueblos, and field trips to archaeological sites in the United States, Mexico, and Guatemala.

Chaco Canyon particularly interested him. He felt that the Chacoans probably used a sophisticated form of astronomy to reckon time and predict celestial events, such as eclipses. His feelings were reinforced by the generally accepted current belief that the Chacoans, or at least an elite of priests and traders among them, were an offshoot of an advanced civilization in Mexico, the most likely being the Toltec. And the Toltecs, Morgan knew, had practiced astronomy and developed an accurate calendar. It seemed only logical to Morgan that the Chacoans, too, would have possessed and used at least some of this knowledge.

But no one has ever unearthed any hard evidence to support this conjecture. The Chacoans had no written language which might have described their astronomical practices. Because of this, most professionals involved in Chacoan research and with whom Morgan has talked give scant credence to the theory.

Morgan decided to investigate independently. If he could not prove his theory scientifically, perhaps he could at least develop some plausible hypotheses. After studying how other ancient people, such as those at Stonehenge in England, may have practiced astronomy, and poring over astronomical records and tables, Morgan, in 1972, felt ready to revisit Chaco Canyon and make careful observations.

The Kiva as a Computer

There are 3 great kivas at Chaco Canyon. One is at Pueblo Bonito. Another is at Chetro Kettle, a principal apartment-town stone edifice which, while smaller than Pueblo Bonito, is equally advanced in architecture. The third is the famous Casa Rinconada, which was an impressive "temple" and gathering place for the tribes and clans of the canyon. In each of the 3 great kivas, a conspicuous feature is a number of niches, or holes, in the cylindrical stone walls. Almost everyone presumes they were built simply to hold religious objects, such as fetishes, and nothing more.

But after making some measurements and puzzling over the niches' peculiarities, Morgan was not disposed to dismiss them quite so lightly.

At the Chetro Kettle kiva, Morgan counted 29 large niches. Why 29? Morgan wondered. That is an awkward number to divide for angular spacing and nothing in his research had revealed any religious significance to the number. There are also 2 small niches "squeezed in" between 2 of the large niches.

Common sense told him that people rarely did things without reason. His mind searched for a possible correlation between the 29 niches and astronomical periods, and he found it in the lunar month. There are approximately 29 sunrises in a lunar month.

Now Morgan could visualize priests tallying the sunrises in a lunar month simply by moving an object from one niche to the next every day. And since there are only approximately 28 moonrises in a lunar month, it would have been a simple matter for the priests to move another marker for moonrises from niche to niche, but skipping the 29th niche.

Although he believed he was on the right track, Morgan felt he had not taken his deductions far enough. The actual periodicity of the moon did not jibe closely enough with the niche theory for his taste. "I felt that an advanced civilization would have known that the lunar period was not exactly 29 days, but 29½ days. Then it dawned on me that the small extra niches could have provided a nearly perfect method for compensating for this discrepancy," Morgan says.

Morgan now visualized only a slightly more complicated, but immensely more accurate, procedure. During the first month of a 2-month period, the priests would have simply moved the markers as Morgan had initially supposed. But during the second month, the priests would have rested the markers in one of the small niches to add an extra count. In this way, the count of niches would have been alternately 29 and 30, averaging 29½, for the sunrise counter and alternately 28 and 29, averaging 28½, for the moonrise counter. This synchronizes well with the nominal 29.53 sunrises and 28.53 moonrises in each lunar month. The kiva would have served both as a memory and as a computer averaging the counts to correspond to the lunar cycle.

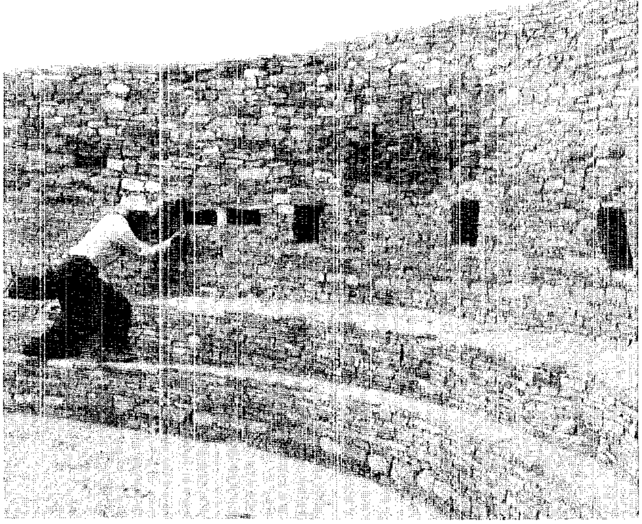
When the Moon Swallows the Sun

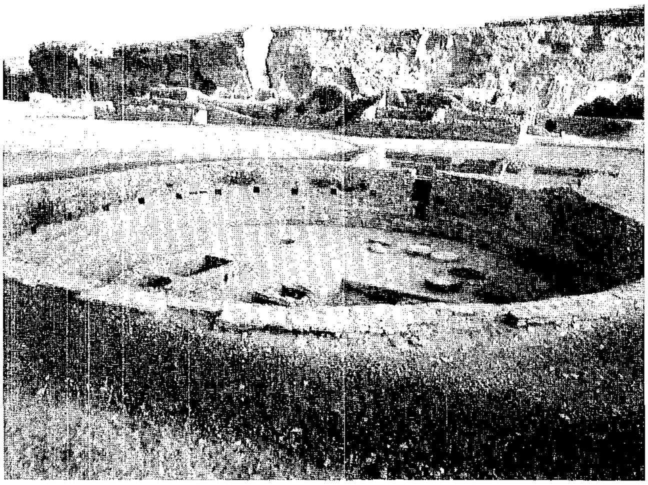
Continuing his cogitations on the niches, Morgan wondered why the 2 small niches had been squeezed in between the 5th and 6th large niches. Why not between the 7th and 8th or the 25th and 26th, for that matter? Was there an astronomical cycle that would "fit" the extra niches?

And in a line of parallel musing, he wondered what astronomical activities would have been most useful to his presumed caste of priest-astronomers. One of the most important, he thought, would be the prediction of solar and lunar eclipses. Such a capability for prophecy, he reasoned, would have made the priests seem omniscient to the unlearned.

An investigation of eclipse records revealed a 41-lunar-month cycle of six 6-month periods plus one 5-month period. Could the 5 segregated niches be used to count this cycle?

In deducing his answer, Morgan recalled that some advanced Central American civilizations had used the zero as a cipher. He assumed that the Chacoans also used the zero as a cipher. On this basis, he visualized moving a special eclipse marker through the 5 large niches for each lunar month, after which the marker would be removed for a month to account for the zero month of each eclipse





Above left, Jim Morgan, CMB-5, measures niches in Chetro Kettle's great kiva, above right. He relates the 29 niches there to the lunar cycle. Below left, Morgan takes compass bearings at sunrise toward distant landmarks from where a tower is believed to have once stood at Chetro Kettle. Below right is a photo Morgan took from the same location on the day of the winter solstice in 1972. Alignment of the rising sun in the distinctive notch may be more than coincidental, Morgan feels.

interval. In accounting for the odd 5-month period, the marker would simply repeat its journey without being removed from circulation.

And, Morgan feels, it would also have been simple to keep track of the 7 periods in the complete cycle by moving another marker through the 5 large niches plus the 2 small niches.

As Morgan explains, "The 6- and 5-month periods are approximations. The exact days of possible solar eclipses are on the new moon closest to the end of an eclipse period and, for a lunar eclipse, on the full moon closest to the end of a period. By combining an accurate count and prediction of new and full moon days with the eclipse cycle, the priests could have issued an eclipse 'alert'."

He doubts that the astronomer-priests had the ability to predict whether a total or partial eclipse, or whether any eclipse at all, would be visible from Chaco Canyon on "alert" days. But Morgan is sure eclipses would never have occurred except on "alert" days, and that the medicine men would never have been embarrassed by an unscheduled eclipse. In fact, they could have taken credit for their prayers and rituals having prevented it if no eclipse were visible at Chaco, or, if an eclipse did occur on schedule, they could have claimed that their "medicine" revived the sun or moon in due time.

The Riddle of 34 Niches

Both the Pueblo Bonito kiva and Casa Rinconada have not 29, but 34 regular niches, plus 2 extra niches. Here Morgan's hypothesis is not quite so neat, is more involved, yet suggests a somewhat more sophisticated "computer" system.

He suggests that one fundamental usage of these niches would be eclipse prediction on a longer time scale. In these kivas, the last 3 niches, numbers 32, 33, and 34, are uniquely positioned and suggest a special significance. Had the month-counting marker been passed once regularly through these niches and then recycled through the same 3 niches, they would have, in effect, added 6 more counts to the overall sequence. This, together with a single use of the small niche, would have generated the 41 counts required to match exactly the 41-lunar-month eclipse cycle. Therefore, by painting or otherwise identifying the proper niches (numbers 6, 12, 18, 24, 30, 36 and 41), an eclipse possibility would have been indicated for the new and full moons of each month in which the marker resided in a specially identified niche.

In like manner, Morgan has explanations for how the niches could have been used for predicting the appearance and disappearance of Venus as a morning or evening "star." Venus is prominent in most Indian mythology. One Toltec belief was that the deified Quetzalcoatl ascended to become Venus.

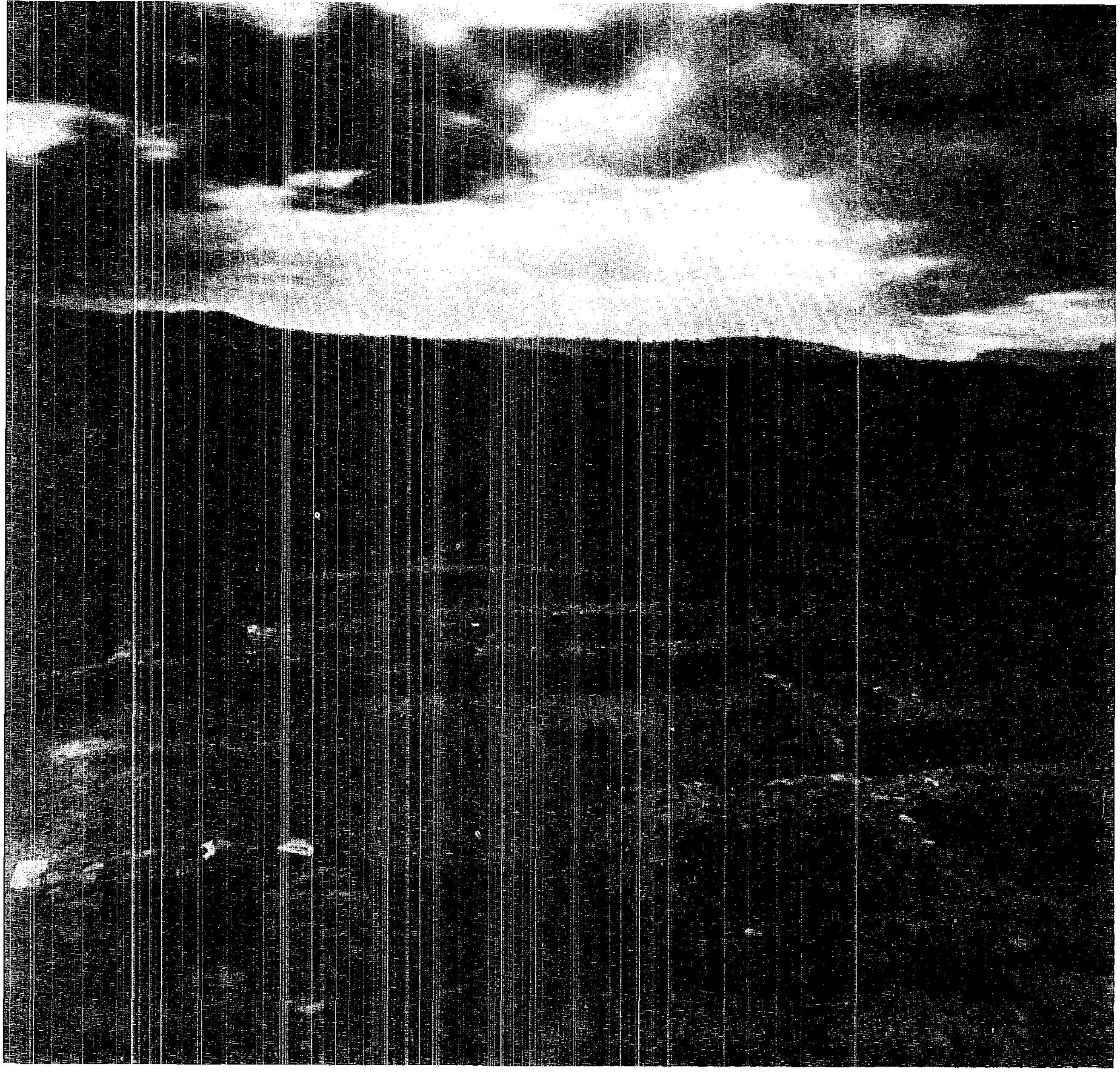
And Morgan has other models showing alternate methods of tallying and computation, such as for the original 10-niche Chetro Kettle kiva which was razed to allow the building of the present kiva.

He also has, by on-site observation, noted various alignments of windows and doorways to niches and between niches and has found relationships to solstice azimuths that he feels are more than coincidental. The solstices—those days of the year when the sun is at the northernmost and southernmost points on the horizon in its apparent north-south migration—are essential to astronomy, providing a precise determination of the solar year, among other things. Nonetheless, he does not feel that the great kivas were observatories, but were computers and perhaps "seminaries" for the instruction of new generations of priestly astronomers; the alignments may have been useful for training and ceremonial purposes. More precise observations, he feels, could have been made from the mesa tops across vast stretches of level land to reference points on distant mountain ranges.

Astronomy as Part of Life

Although conceding that "hard" evidence may never be unearthed to corroborate his hypotheses, he feels he has shown that astronomy may have been practiced, as well as how it could have been practiced, at Chaco Canyon.

At left, the first rays from the rising sun shine through the only window of the Casa Rinconada great kiva on July 13. The beam strikes a point just above an unusually placed niche as Morgan prepares to record its movement photographically, below left. A few minutes later, below, the beam, shining through the window (A), strikes a point level with, but a few degrees to the right of, the niche (B). Simple calculations show it would have struck the niche itself on the summer solstice 3 weeks earlier.



The great kiva of Pueblo Bonito under a summer moon.

Why it was practiced seems clear to him. Two practical applications could have been the timing of the planting of crops and the scheduling of religious events. More than that, the movements of celestial bodies universally awed ancient man and were associated with supernatural forces. The ability to predict the movements of celestial bodies and astronomical events months and years in advance would have enhanced the already formidable prestige of a learned priestly caste.

Perhaps what is most important, Morgan feels, is that the ancient Indian (as well as many of his modern counterparts) must have sensed cyclical patterns in the natural world of which he was so much a part. He could not have helped but notice cycles in tides and weather, in the reproduction and migration of wild life, in the germination and growth of vegetation, and in many other things. Unlike modern man who tends to compartmentalize religion, the Indian believed that spirits, cosmic or otherwise, were an integral part of the world in which he lived and were forces with which he must live in harmony.

Thus, as the ancient Indian viewed his rhythmic world of birth, death, and regeneration, the ability to relate these cycles to those he saw in the sky must have been a source of understanding and confidence.

To Morgan, all of this explains the ancient Indian's intense interest in astronomy and why he achieved a high degree of proficiency in it. That it may have reached such heights in Chaco Canyon is a tribute to the magnificent civilization that Morgan believes flourished in New Mexico 400 years before the conquistadores arrived.

Armistead Named New Editor of *The Atom*

Armistead Named New Editor of *The Atom*

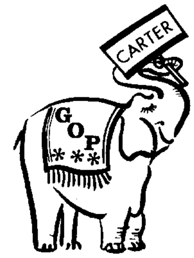
John C. Armistead has joined Group ISD-1 as editor of *The Atom.* He replaces Jack Nelson who has resigned to return to free-lance writing and photography.

Armistead earned his B.A. in journalism from Texas Tech University, Lubbock, Texas, in 1971. He has served in a variety of capacities on both weekly and daily newspapers in the past decade, and was public affairs officer for the Texas Department of Highways and Public Transportation before moving to Santa Fe in June.

A U.S. Navy veteran, he was editor of a weekly newspaper at the U.S. Naval Station on Kodiak Island, Alaska, which was judged best newspaper in the Navy in its category in 1969.

Armistead's wife, Barbara, is a teacher at New Mexico School for the Deaf, Santa Fe.

10 *years ago in los alamos*



Culled from the July and August, 1966, files of The Atom and the Los Alamos Monitor by Robert Y. Porton

Farewell?

It will all be over this month. The last of the guests and the diners will cross the red-tiled threshold, somebody will lock the doors, and Fuller Lodge will end its 38 years as the center of a remarkable assortment of activities on the Pajarito Plateau. For future Hill visitors, the dark confines of the old hotel will be replaced by the sparkling new Los Alamos Inn. But it just won't be the same. No schoolboy ever carved his initials on the new chairs nor received his diploma under the portal. No Town Council met at the Inn to discuss wartime shortages, the right to vote, or the mysterious ways of the Army. Enrico Fermi never slept there, neither did Niels Bohr nor Ernest Lawrence. The end of The Lodge as a hotel seems almost the biggest of many steps in the transformation of Los Alamos from a unique community of the past to a modern town of the future.

Ceremony

Laboratory Director Norris Bradbury and W-Division leader Harold Agnew attended a special ceremony at the White House August 1, commemorating the 20th anniversary of the signing of the Atomic Energy Act. Also present were General Leslie Groves, who was director of the Manhattan District during the early days of the Laboratory; I. I. Rabi, Nobel Laureate; William L. Laurence, a **New York Times** reporter who chronicled the Trinity Test; and all members of the Joint Congressional Committee on Atomic Energy.

Republicans Back Carter

Several Los Alamos Republicans attended the July 8 opening of the Carter for U.S. Senate state headquarters in Albuquerque. According to Toby Seger, Los Alamos coordinator for the state candidates, the campaign for the Senate will be a long and hard-fought one. He says Anderson Carter, the G.O.P. candidate, is a young man with ideas and that he intends to take his campaign directly to the people of the state.

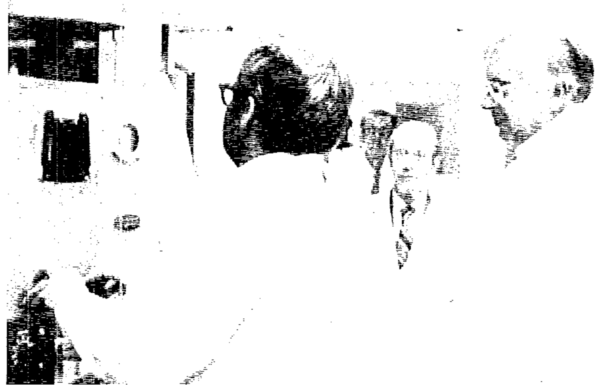
Among Our Guests

Eugene P. Wigner, who received a Nobel Prize in physics in 1963, spoke on "Civil Defense in the USSR" at a colloquium at LASL on June 22. Wigner, educated in Germany and recipient of honorary degrees from more than 15 universities, has been awarded a number of honors in addition to the Nobel Prize. These include the Enrico Fermi Award in 1958, The Atoms for Peace Award in 1960, and the Albert Einstein Award in 1972.

Director Harold Agnew hands a hemisphere of plutonium to Chris Mauldin, wife of cartoonist Bill Mauldin, left. The Mauldins, accompanied by Bill's mother, toured LASL in June. (For more on plutonium handling, see the back cover.)

Thomas Reed, Secretary of the Air Force, talks with Harry Hoyt, assistant director for weapon planning, right, and Robert Thorn, associate director for weapons, left. Reed visited LASL on June 1 for a series of briefings on Laboratory programs.

Elmer B. Staats, Comptroller General of the United States, and Frank DiLuzio, assistant to the Director for planning, right, visit in the minutes before commencement of a June colloquium at which Staats spoke on "Recent Developments in Science and Technology: Progress and Concerns."



S. William Gouse, ERDA deputy assistant administrator for fossil energy, visited LASL in June and is shown in the analytical chemistry laboratory in the CMR building. With Gouse are E. A. Hakkila, CMB-1, left, Glenn Waterbury, CMB-1 group leader, background, and Richard D. Baker, CMB division leader, center.

David Saxon, above.
Mrs. Dean Watkins, below.

Mrs. David Saxon, above.
Earl Willens, below

Mrs. Edward Morris, below.

Edward Morris, below.

Why Are These People Smiling?

They're smiling with surprise and perhaps just a bit of trepidation because they're holding, somewhat gingerly, a sample of warm plutonium handed to them by Laboratory Director Harold Agnew during the group's recent Laboratory visit. Although the members of the group all knew that plutonium, when properly processed, formed, and encapsulated, is a perfectly safe material, there is nothing like a "first-hand" experience such as this to underscore the point.

The group, which visited the Laboratory on June 10 and 11, was a distinguished one: Regents and officials of the University of California and their wives. They received an overview of Laboratory activities during 2 days of presentations, discussions, tours, luncheons, and dinners. The Laboratory's guests were:

- Dr. John H. Lawrence, *Regent;*
- Mr. and Mrs. Edward Morris, *Regent and President of the University of California Alumni Association;*
- Dr. and Mrs. David S. Saxon, *Regent and President of the University;*
- Mr. Earl P. Willens, *Regent Designate;*
- Mr. and Mrs. Donald L. Reidhaar, *Chief Counsel of the Regents;*
- Dr. John A. Perkins, *Vice President, Business and Finance;*
- Dr. Edward E. Teller, *Professor Emeritus;*
- Dr. Glenn Campbell, *Regent;*
- Dr. and Mrs. Dean A. Watkins, *Regent.*